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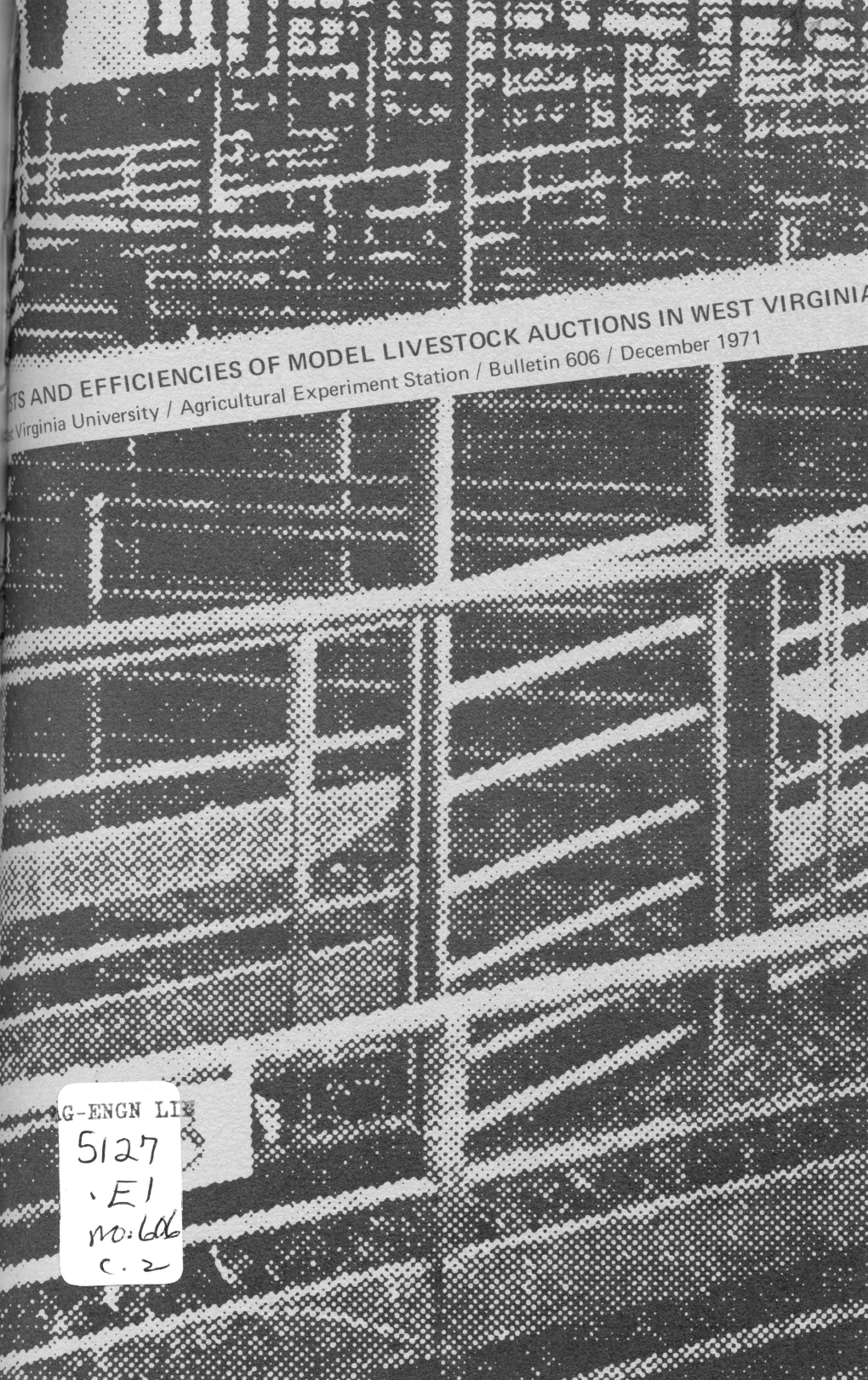
Costs and efficiencies of model livestock auctions in West Virginia

John P. Kuehn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Virginia University / Agricultural Experiment Station / Bulletin 606 / December 1971
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SUMMARY

The objectives of this study were to synthetically determine the costs of operating "efficient" *model* livestock auctions which could be constructed and operated in West Virginia and to compare the unit costs of these model firms to those of the existing livestock auctions in the State. It was hoped that this comparison would allow evaluation of the West Virginia auction industry on the basis of relative efficiency. The results of this procedure were hypothesized to be helpful in determining the nature and causes of trends in West Virginia towards fewer livestock auctions and a declining volume of livestock being marketed through auctions.

The procedure used to accomplish these objectives was synthetic cost analysis or economic engineering. Physical input-output standards were determined and costs were assigned to them. The resulting cost functions were derived for each stage of operation of a livestock auction until they could be summed to form the cost function for an entire firm. Output of each model firm was then determined, based on engineering designs and on the actual seasonal marketings of livestock in West Virginia. Output was then assumed to vary and costs per unit of output were determined for each model auction under varying rates of output. This procedure was followed for three model auctions with daily designed capacities of 500, 1,500, and 2,500 animal units.

The unit costs derived by means of economic engineering were compared to unit costs of actual firms in West Virginia. It was found that, within the range of output of the existing firms in the State, the actual unit costs were similar to the engineered costs which were defined as "efficient." The average revenue per animal unit marketed through livestock auctions was then determined and it was found to be lower than the average cost per animal unit for the average of West Virginia auction markets. The average auction fee per animal unit in West Virginia was found to be $3.49, but the average cost was $3.66, indicating that many firms in the State are facing losses, perhaps just covering their variable costs. This problem is compounded by the conclusion of this study that actual firms in the State are operating efficiently, inferring they can only decrease their unit costs by increasing the volume of animals marketed through them.

It appeared from the results of this study that the number of auctions in the State will continue to decrease until the volume of livestock marketed through the surviving auctions becomes large enough to decrease costs per unit of output. This process could continue until unit costs of the West Virginia auctions more closely approach average revenues or fees per animal unit.

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Cost and Efficiencies of Model Livestock Auctions in West Virginia

JOHN P. KUEHN

The West Virginia livestock industry is primarily a beef cow-calf economy. Of the 461,000 cattle and calves on West Virginia farms as of January 1, 1969, 42.5 per cent were cows, two years and older; 7.6 per cent were one-to two-year-old heifers; 7.8 per cent were steers, one year and older; 2.0 per cent were bulls, one year and older; and 19.1 per cent were calves. The rest (21.0 per cent) were kept for purposes of milk production.[1]

The primary method of marketing West Virginia livestock has been through livestock auction markets. However, in the 1960's the auction sector of the West Virginia agricultural economy appeared to begin declining. Of the 23 auctions operating in the State in 1950, 20 remained in 1968 and 19 in 1969.[2] There was also a decline in the volume of livestock marketed through West Virginia auctions during the period. The number of cattle and calves marketed through West Virginia auctions decreased from 252,705 in 1961 to 197,444 in 1968. Hogs marketed decreased from 64,553 in 1961 to 55,044 in 1968 and sheep and lambs marketed through auctions decreased from 167,702 to 108,476 from 1961 to 1968.[3]

It is apparent from the statistics that the West Virginia livestock industry is undergoing significant changes. The overall objective of livestock marketing research is to improve efficiency, thereby increasing the incomes and well-being of our agricultural population. The first of a series of Experiment Station bulletins on West Virginia livestock marketing examined the operating practices and costs of the auction markets in the State.[4] The objective of the present study is to provide a comparison of efficiency between the operating practices and costs of actual auction markets and the operating practices and costs which would be incurred by "efficient" model auction market operations.

Hopefully, such a comparison would isolate some of the problems which have been occurring in the West Virginia livestock industry and possibly point out some alternative measures which could be used to alleviate these problems.

[1]United States Department of Agriculture, *Livestock and Meat Statistics,* Supplement for 1968 to Statistical Bulletin No. 333, Economic Research Service, Washington: U. S. Government Printing Office, July, 1969, p. 8.

[2]Wilson, E. M. and J. P. Kuehn, *A Cost Analysis of the Livestock Auction Markets in West Virginia,* West Virginia Agricultural Experiment Station Bulletin 600T, April, 1971, p. 8.

[3]Wilson and Kuehn, *op. cit.,* p. 9.

[4]*Ibid.*

OBJECTIVES AND PROCEDURE

The specific objectives of this study were: (1) to synthetically determine the costs of operating efficient model livestock auctions which could be constructed and operated in West Virginia; and (2) to compare the operating costs of efficient model auctions to those of the existing livestock auctions in the State. It was hoped that a comparison such as this one would permit evaluation of the West Virginia auction firms on the basis of relative efficiency. The results of this procedure could then be helpful in determining the causes of trends in the West Virginia livestock industry towards fewer livestock auctions and a smaller proportion of the total inventory of livestock being marketed through auctions.

The procedure used to accomplish these objectives was synthetic cost analysis, or economic engineering. This technique first involves the determination of physical input-output coefficients or standards (for example, the time required for an efficient yard-worker to sort one animal). Costs are then assigned to these standards (the West Virginia wage rate for yard-workers is $1.60 per hour) and cost functions are derived for each stage of operation of the model auction market (labor costs, building cost, utilities, etc.). The cost functions for each operational stage are added together to form the plant cost function. The output of the firm in animal units is then determined so that average costs or costs per animal unit of efficient model auctions can be calculated. Output is then varied to determine the behavior of costs under different levels of utilization of capacity.

The above procedure was followed for three different size model auctions. The daily capacity of these auctions was assumed to be 500, 1,500, and 2,500 animal units.

DESCRIPTION OF THE MODEL LIVESTOCK AUCTIONS

Engineering designs of the prospective model firms must be secured in order to conduct an economic engineering or synthetic cost study. Fixed and variable costs then can be synthesized based on the physical input-output characteristics of the model designs.

Three different size model auctions were designed using the criterion that it would be economically feasible for any of them to be constructed and operated in West Virginia. They were to use the most advanced technology available, *i.e.*, the best organization and most efficient utilization of resources.

The sizes of the model auctions were measured in terms of animal units. Since most auctions handle several different species of animals, the use of common animal units facilitates cost comparisons of different auctions. It was assumed that an animal unit consisted of one "cattle" or two calves, or four hogs, or four sheep or lambs. This ratio was based on the space requirement of cattle of 20 square feet each, calves ten square feet each, and hogs, sheep, and lambs five square feet each.

Auctions in West Virginia handle other species of animals (horses, chickens, etc), and miscellaneous items of farm equipment. However, the dollar turnover accounted for by the latter articles was judged to be insignificant. The other animals and items of farm equipment were therefore omitted for purposes of cost analysis. "All" livestock in this study, then, consisted of cattle, calves, hogs, sheep, and lambs only.

Model auctions of 500, 1,500, and 2,500 animal unit capacities were chosen for this study. These sizes were decided upon in order to cover a range of sizes large enough to include the existing firms in West Virginia and larger sizes which could tentatively exist in the State. The larger sizes were included in order to test the hypothesis that average costs decrease as auction size increases.

Operating Characteristics

It was assumed the model auctions would operate in a similar manner to the existing firms in West Virginia. Animals were assumed to be weighed and graded as they entered the market and there was to be only one sale day per week.[5]

MODEL AUCTION OUTPUT

Animal Units

The output of each of the model auctions was calculated in terms of animal units. It was found that between 1961 and 1968, 1,191,774 cattle, 740,952 calves, 485,417 hogs, and 1,064,134 sheep and lambs were marketed through West Virginia auctions.[6] Since an animal unit was composed of a 1:2:4:4 ratio of cattle to calves to hogs to sheep and lambs, 1,191,774 animal units of cattle, 370,476 animal units of calves, 121,354 animal units of hogs, and 266,034 animal units of sheep and lambs were marketed through West Virginia auctions between 1961 and 1968. This meant that of the total number of animal units marketed in West Virginia between 1961 and 1968, 61 per cent were cattle, 19 per cent were calves, six per cent were hogs, and 14 per cent were sheep and lambs. It was therefore assumed that of each animal unit marketed by the model auctions, 61 per cent would be accounted for by cattle, 19 per cent by calves, and 6 and 14 per cent would be accounted for by hogs and sheep and lambs, respectively.

Seasonal Index

The existing auction markets in West Virginia were each designed to handle a certain number of animals when operating at capacity. However, due to the

[5]For a more detailed description of the operating characteristics of West Virginia auction markets, see Wilson, E. M. and J. P. Kuehn, *op. cit.*, pp. 12-15.

[6]Calculated from the Annual Reports of Livestock Auction Markets to the Commissioner of Agriculture, West Virginia Department of Agriculture, 1961-1968.

seasonal nature of livestock marketings in the State, a particular auction rarely operates at full capacity. An objective of this analysis was to examine the behavior of auction costs of "efficient" model firms under expected West Virginia operating conditions. It was therefore necessary to make some assumptions regarding the level of utilization of capacity in the model auctions.

In order to determine the nature of the seasonality of livestock marketing in West Virginia a seasonal index was derived. This was accomplished by using the "method of ratios to moving averages."[7] The number of each species of livestock marketed through West Virginia auctions by month in 1967 and 1968[8] was converted to animal units. First a 12-month centered moving average was taken and then ratios to moving average were computed by dividing the actual data by the centered moving average for each month. The ratios were adjusted and multiplied by 100 to form a seasonal index (Table 1).

This seasonal index shows, by months, the pattern of livestock marketed through auctions in terms of animal units based on 1967 and 1968 figures.

Capacity Index

In order to make this index useful in determining the total output of the *model* auctions, it was necessary to convert the seasonal index to a capacity index. A market needs the capacity to handle all animals submitted on sale days during its busiest month. According to the seasonal index, this high month was October. Therefore, it was assumed that the number of animal units marketed through a model auction in October was 100 per cent, or full capacity. All other monthly index figures were taken as a percentage of the October figure to form the capacity index. It could then be assumed that a particular *model* auction would operate at full designed capacity during October, at 60.0 per cent of capacity during November, 20.1 per cent of capacity during December, etc. (Table 1).

Annual Output

The capacity index was then used to determine the annual outputs of the three model auctions. Since model auction A was designed to handle 500 animal units at capacity, it was assumed to handle 500 animal units on each of the sale days in October. The amounts handled on sale days during other months of the year were some proportion of the capacity of 500 animal units depending on the capacity index. Table 2 shows annual outputs of the three model auctions in terms of animal units and in actual species of livestock.

[7]Bryant, Edward C., *Statistical Analysis,* New York: McGraw-Hill Book Co., 1960, pp. 192-193.

[8]Taken from the Annual Reports of Livestock Auction Markets to the West Virginia Department of Agriculture, 1967 and 1968.

TABLE 1

Monthly Seasonal and Capacity Indexes of Livestock Marketed Through West Virginia Livestock Auctions, 1967-1968

Month	Seasonal[a] Index	Capacity[b] Index
January	52.7	18.7
February	37.8	13.4
March	52.1	18.5
April	101.6	36.1
May	54.2	19.3
June	62.2	22.1
July	78.5	27.1
August	95.4	33.9
September	158.9	56.5
October	281.1	100.0
November	168.6	60.0
December	56.4	20.1

[a]Calculated by means of the "method of ratios to moving averages" explained in Bryant, Edward C., *Statistical Analysis,* New York: McGraw-Hill Book Co., 1960, pp. 192-193.

[b]October, the high output month in the seasonal index was assumed to be the base month where all model auctions operated at full capacity. All other months in the seasonal index were taken as a percentage of the base month to form the capacity index.

TABLE 2

Annual Output of the Model Auction Markets in Animal Units and by Actual Species of Livestock

Model Plant	Annual Output of All Species[a] (Animal Unit)	Cattle[b] (Number)	Calves[c] (Number)	Hogs[d] (Number)	Sheep & Lambs[e] (Number)
A	9,240	5,636	3,512	2,216	5,176
B	27,720	16,909	10,534	6,652	15,524
C	46,200	28,182	17,556	11,088	25,872

[a]Calculated from the capacity index. The three model auctions were assumed to have capacities of 500, 1,500, and 2,500 animal units, respectively.

[b]Sixty-one per cent of all animal units were assumed to be cattle based on actual figures from 1961 to 1968. (See section on Animal Units.)

[c]Nineteen per cent of all animal units were calves. Two calves equal one animal unit.

[d]Hogs accounted for six per cent of all animal units and there are four hogs per animal unit.

[e]Sheep and lambs accounted for 14 per cent of all animal units and there are four sheep or lambs per animal unit.

LABOR REQUIREMENTS AND COSTS

Auction market labor requirements and costs were synthesized for each of the model livestock auctions. The categories of labor for each model auction included yard and ringmen, weighmen, graders, secretaries, auctioneers, a bookkeeper, and an auction manager.

The fact that livestock auction markets in West Virginia are only allowed to conduct sales one day per week presents problems to auction managers in hiring labor. A manager has the problem of finding experienced workers willing to work for only one or two days each week. He also has the problem of determining how many part-time employees to hire each week when he is not sure of the number of animals that will be consigned for sale.

In this study the labor costs were calculated on the basis of labor time requirements per animal unit that was assumed to be handled by the model livestock auctions. The labor costs derived in this manner therefore did not

reflect the influence of uncertainty in hiring and managing the labor inputs. These cost figures should therefore be useful as indicators of costs incurred in highly efficient auction market operations.

Yardmen and Ringmen

Murra and Mire investigated the livestock auction markets in Louisiana and found that yardmen and ringmen work 25 minutes per animal unit in small auctions (less than 15,000 animal units annually), 21.4 minutes in medium size auctions (15,000 to 30,000 animal units), and 18 minutes per animal unit in large auctions (30,000 animal units and over).[9]

Murra and Mire used different coefficients for animal units than were used in the present study. They assumed one head of cattle or one calf was equivalent to three hogs or seven sheep.[10] In order to overcome this incompatibility, the Louisiana animal units were converted into equivalent animal units that were being used in the present study (one cattle: two calves: four hogs: four sheep or lambs). It was calculated that .995 Louisiana animal unit was equivalent to one animal unit in this study.

The number of minutes per animal unit required of yard and ringmen for small, medium, and large auctions in Louisiana was converted and used to estimate yard and ring labor costs for model plants A, B, and C in West Virginia. It was found that the number of hours required per week for the model auctions were 74.4, 191.1, and 267.9 for model firms A (9,240 AU's per year), B (27,720 AU's per year), and C (46,200 AU's per year), respectively. According to the West Virginia Department of Employment Security the expected wage rate for this type of employment is $1.60 per hour. The annual cost of yard and ringmen for the three model auctions was found to be $6,513, $16,725, and $23,445 for model auctions A, B, and C, respectively. These figures include social security payments of 5.2 per cent of employee income up to the first $7,800 per employee.

Weighmen

Murra and Mire found that it costs $0.08, $0.06, and $0.05 per animal unit to weigh livestock in Louisiana in small, medium, and large size auctions.[11] These figures were used to estimate the cost of weighing livestock in the West Virginia model auctions. The cost coefficients were first adjusted for the difference in calculation of animal units and since the Louisiana figures were dated 1964, they were inflated by the index of Prices of Selected Farm Inputs

[9]Murra, G. E. and Thomas G. Mire, *The Organization, Operation, and Costs of Livestock Auctions in Louisiana,* D. A. E. Research Report No. 361, Baton Rouge, Louisiana State University Agricultural Experiment Station, April, 1967, p. 30.

[10]*Ibid.,* p. 8.

[11]*Ibid.,* p. 33.

from 1964 to 1970.[12] The increase in the price index from 1964 to 1970 was 55.2 per cent. The figures calculated for the annual cost of livestock weighmen, including social security payments, in model plants A, B, and C were $1,213, $2,730, and $3,791, respectively.

Graders

Lambs, veal calves, and stocker calves are graded by the West Virginia Department of Agriculture, and according to officials at that department, the charge is $0.03 per lamb, $0.07 per veal calf, and $0.10 per stocker. It was calculated that 10 per cent of all animal units marketed through West Virginia auctions were lambs, 5.3 per cent were graded veal calves, and 1.9 per cent were stockers.[13]

These percentages were used to estimate the number of lambs, veal calves, and stockers graded in the model livestock auctions and it was found that the annual cost of graders in the model auctions was $215, $644, and $1,583 for model auctions A, B, and C, respectively.

Secretaries

Several auction owners and West Virginia Department of Agriculture personnel were interviewed and it was found that two part-time secretaries were needed for each of the model auctions. Time requirements per sale were eight hours each in auction A, 10 hours each in auction B, and 12 hours each in auction C. According to the West Virginia Department of Employment Security, the wage rate for secretarial employees is $1.75 per hour. The annual cost of secretarial employees in the model auctions, including social security payments was $1,532, $1,915, and $2,298 for auctions A, B, and C, respectively.

Auctioneers

Several personal interviews with auction personnel and West Virginia Department of Agriculture representatives revealed the expected requirements and costs of auctioneers for the model livestock auctions. One auctioneer per sale was required for auctions A and B and two auctioneers were required for auction C. The cost per auctioneer per sale was $50 for firms A and B and $75 for each of the auctioneers required in firm C. The total annual costs, including social security, for the three model operations were $2,735 for model auctions A and B and $8,206 for model auction C.

Bookkeeper

It was found by means of personal interviews with West Virginia

[12]Index of Selected Farm Inputs, *1970 Handbook of Agricultural Charts,* Ag. Handbook No. 397, U.S.D.A., Washington: U. S. Government Printing Office, 1970, p. 10.

[13]Calculated from the 1961 to 1968 Annual Reports of Livestock Auction Markets to the Commissioner of Agriculture, West Virginia Department of Agriculture, Charleston.

Department of Agriculture personnel that one bookkeeper would be required for each of the model plants. The number of hours of work required of each would be 8, 18, and 20 hours per week for model auctions A, B, and C, respectively. According to the West Virginia Department of Employment Security, the 1970 wage rate for bookkeepers was $2.50 per hour. Accordingly, the annual cost, including social security, for bookkeepers would be $1,094 for model firm A, $2,462 for model firm B, and $2,735 for model firm C.

Auction Manager

Murra and Mire found that salaries of auction managers for small, medium, and large auctions in Louisiana were $0.36, $0.17, and $0.12 per animal unit.[14] These coefficients were adjusted for the difference in calculation of animal units between the Louisiana study and the West Virginia study. They were then adjusted for the price level change between 1964 and 1970. The annual cost of management, then, for the three model auctions was $5,458, $7,732, and $9,098, including social security.

Total Labor Cost

The calculated annual labor cost for each of the categories of labor and the total and average annual labor cost for each model auction are summarized in Table 3. The cost of labor per animal unit decreased from $2.03 to $1.11 as annual auction output increased from 9,240 to 46,200 animal units.

The synthetically determined labor costs can be compared to actual figures that were determined for West Virginia. Wilson and Kuehn found total labor costs per livestock marketing unit[15] amounted to $1.97 in auctions handling 6,000 to 11,999 L.M.U.'s and $2.11 in auctions handling over 12,000 L.M.U.'s.[16] The cost per animal unit in the present study can be converted to L.M.U.'s since one animal unit is equivalent to 1.130 L.M.U.'s. The comparable (synthesized) figures are from model plants A (9,240 animal units per annum) and B (27,720 animal units per annum) whose converted average labor costs are $2.02 and $1.25 per L.M.U.

Model Auction A	**Actual W.Va. Auctions**[17]
9,240 A.U.'s per year	6,000 to 11,999 L.M.U.'s per year
$2.03 per A.U. or $2.02 per L.M.U.	$1.97 per L.M.U.
Model Auction B	**Actual W.Va. Auctions**
27,720 A.U.'s per year	12,000 L.M.U.'s per year and over
$1.26 per A.U. or $1.25 per L.M.U.	$2.11 per L.M.U.

[14]Murra and Mire, *op. cit.*, p. 33.

[15]One livestock marketing unit (L.M.U.) was equivalent to one "cattle" or three calves or four hogs or five sheep or lambs.

[16]Wilson and Kuehn, *op. cit.*, p. 26.

[17]*Ibid.*

TABLE 3

Calculated Total and Average Annual Labor Costs of the Model Auctions by Class of Labor

Class of Labor	Plant A	Plant B	Plant C
Yard and Ringmen	$ 6,513	$16,725	$23,445
Weighmen	1,213	2,730	3,791
Graders	215	644	1,583
Secretaries	1,532	1,915	2,298
Auctioneers	2,735	2,735	8,206
Bookkeeper	1,094	2,462	2,735
Manager	5,458	7,732	9,098
TOTAL	**$18,760**	**$34,943**	**$51,156**
Annual Output	**9,240 A.U.'s**	**27,720 A.U.'s**	**46,200 A.U.'s**
Labor Cost per A.U.	**$2.03**	**$1.26**	**$1.11**

The synthesized labor costs are very similar to the actual average costs in the smaller auctions. However, the larger auctions exhibit a large divergence in labor cost per animal unit. The synthesized model auction B has substantially lower labor cost per animal unit than the actual larger West Virginia auctions. This discrepancy implies that the larger existing auctions in the State could decrease costs by improving the efficiency of labor utilization.

BUILDING REQUIREMENTS AND COSTS

The criterion used in designing the buildings, which were assumed to be used in the model auctions of this study, was that they be composed of the most economically efficient design and organization of facilities available. The original design of buildings for the model auctions was supplied by United States

Department of Agriculture personnel[18] and was modified for use in West Virginia by personnel of the West Virginia Department of Agriculture and the Agricultural Experiment Station.

The nature, characteristics, and costs of construction materials that were assumed to be used in the model auctions, were taken from published U.S.D.A. guidelines for the construction of livestock auction markets in the Appalachian area.[19] Some cost figures in the above publication by Brasington were modified by converting them from absolute costs to a cost per animal unit basis when necessary, in order to utilize his cost figures in different size model auction markets.

Brasington presented three auction market designs with a construction cost breakdown accompanying each design. Each of his markets was designed to handle a different number and combination of animals.[20] In order to use his cost figures then, they had to be converted to the same animal unit basis being used in the present study. In the case of hayracks, feed troughs, water troughs, water lines and lighting fixtures, the costs per animal unit were averaged for each of his three designed markets. These costs per animal unit were then updated from 1957 to 1970 in order that they be used in the present study.

The remaining costs presented by Brasington were on a unit basis (cost per square foot or cost per item) and were adjusted for price level changes and used with the building requirements of the model auctions designed for the present study.

Figures 1-3 show the designs of the model auctions with the exception of the sales barn, restaurant, offices, rest, and storage rooms. The latter areas were assumed to be the same as those designed by Brasington.[21] Tables 4, 5, and 6 show the building construction unit and total costs for the three model livestock auctions.

BUILDING DEPRECIATION

The buildings were depreciated on the basis of 25 years of expected life, or four per cent of the total cost per year. Building depreciation in auction A was $3,587, and the depreciation for auctions B and C was $8,070 and $12,489, respectively.

[18]The original designs were supplied by Mr. Herman Mayes, Agricultural Engineer, Transportation and Facilities Research Division, United States Department of Agriculture.

[19]Brasington, Clayton F., *Livestock Auction Markets in the Appalachian Area—Methods and Facilities,* Marketing Research Report No. 309, A.M.S., U.S.D.A., Washington: U.S. Government Printing Office, 1959.

[20]*Ibid.*

[21]*Ibid.,* p. 30

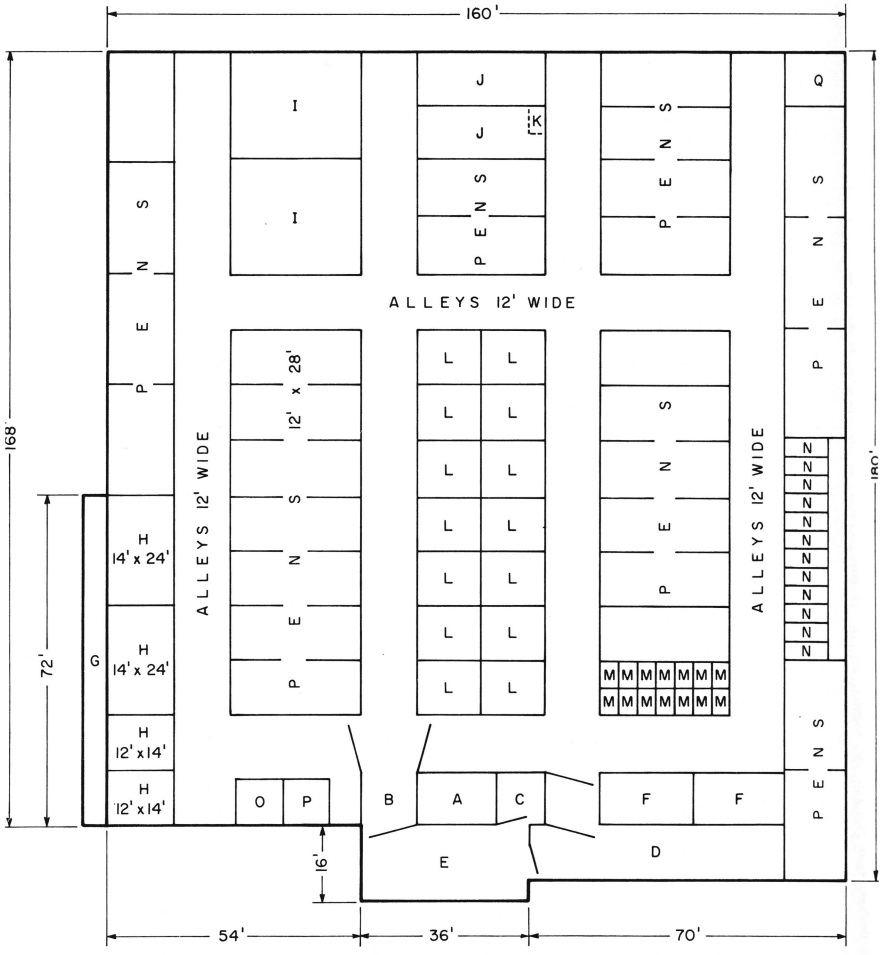

Figure 1. Model Auction A, 500 Animal Unit Daily Capacity.

EQUIPMENT REQUIREMENTS AND COSTS

The amount of equipment required to operate a livestock auction is relatively limited. There were three main categories of equipment considered in this study: (1) cleaning equipment for pens and alleys, (2) restaurant equipment, and (3) office equipment.

Cleaning Equipment

According to West Virginia Department of Agriculture personnel and several auction managers, pens and alleys are cleaned two to four times per year. The manure and bedding that is removed is then sold. Some auctions allow outside

KEY TO FIGURES 1, 2, and 3

A = Auction booth
B = After sale holding pen (10' x 10')
C = Cut-off pen (10' x 10')
D = Main alley to ring
E = Sales ring (16' x 30')
F = Sorting pens (10' x 20')[a]
G = Unloading and loading dock (small and large truck)
H = Unloading and loading pens[a]
I = Cow pens (24' x 28')
J = Bleeding and vaccinating pen (12' x 28')[a]
K = Chute for J
L = Veal pens (12' x 14')[a]
M = Small animal pens (4' x 6')[a]
N = Bull pens (4' x 10')[a]
O = Holding pen for scale (10' x 10')[a]
P = Scale (10' x 10')
Q = Dipping vat pen (12' x 14')[a]

[a]Pens were presented in these diagrams without showing the locations of gates. They were shown in this manner for purposes of clarity of presentation. It was assumed the gates could be placed on one or more sides of any pen and could be opened in any direction.

Source: These figures were based on designs contributed by Mr. Herman Mayes, Agricultural Engineer, Transportation and Facilities Research Division, U.S.D.A. The designs were modified for use in West Virginia by representatives of the State Department of Agriculture and the Agricultural Experiment Station. The design of the sales barn including offices, rest rooms, restaurant, and storage areas was presented by Brasington, *op. cit.*, pp. 30-31. It was assumed that his design would be used for the model auctions of this study but the sizes of the arena were assumed to change as seating requirements changed in the larger model auctions.

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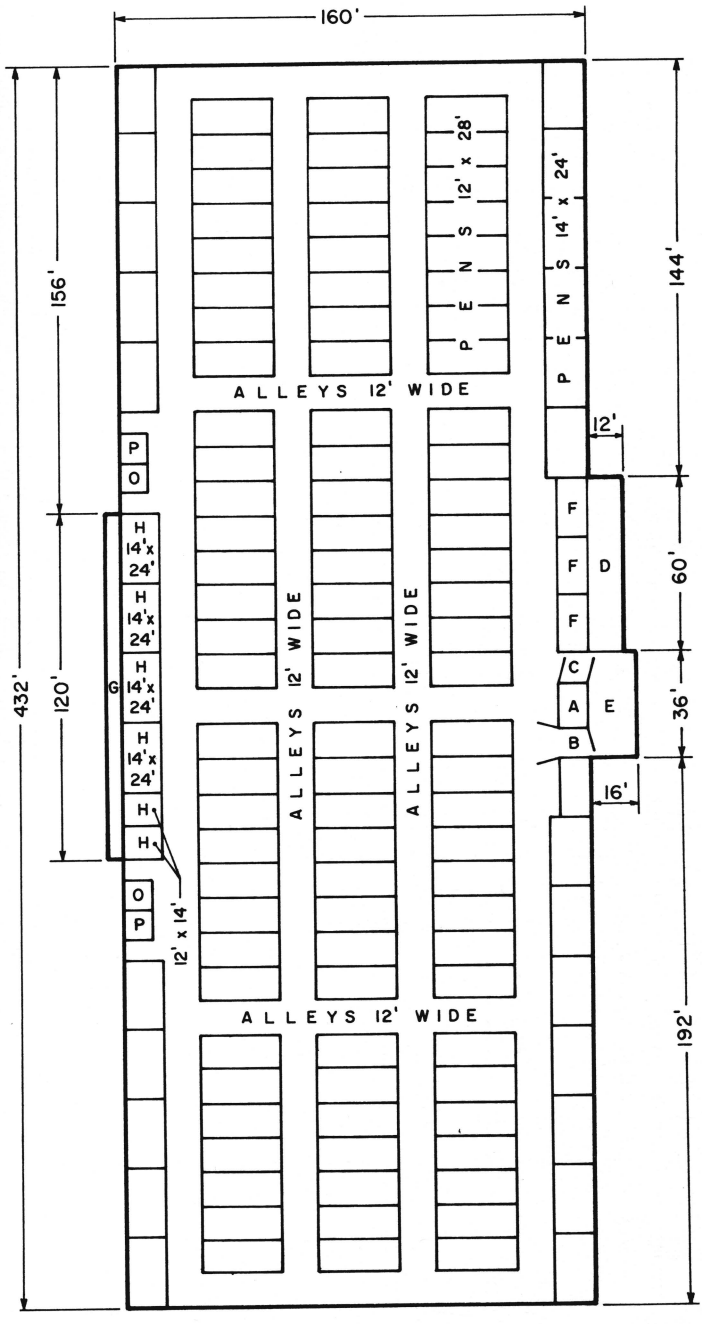

Figure 2. Model Auction B, 1,500 Animal Unit Daily Capacity.

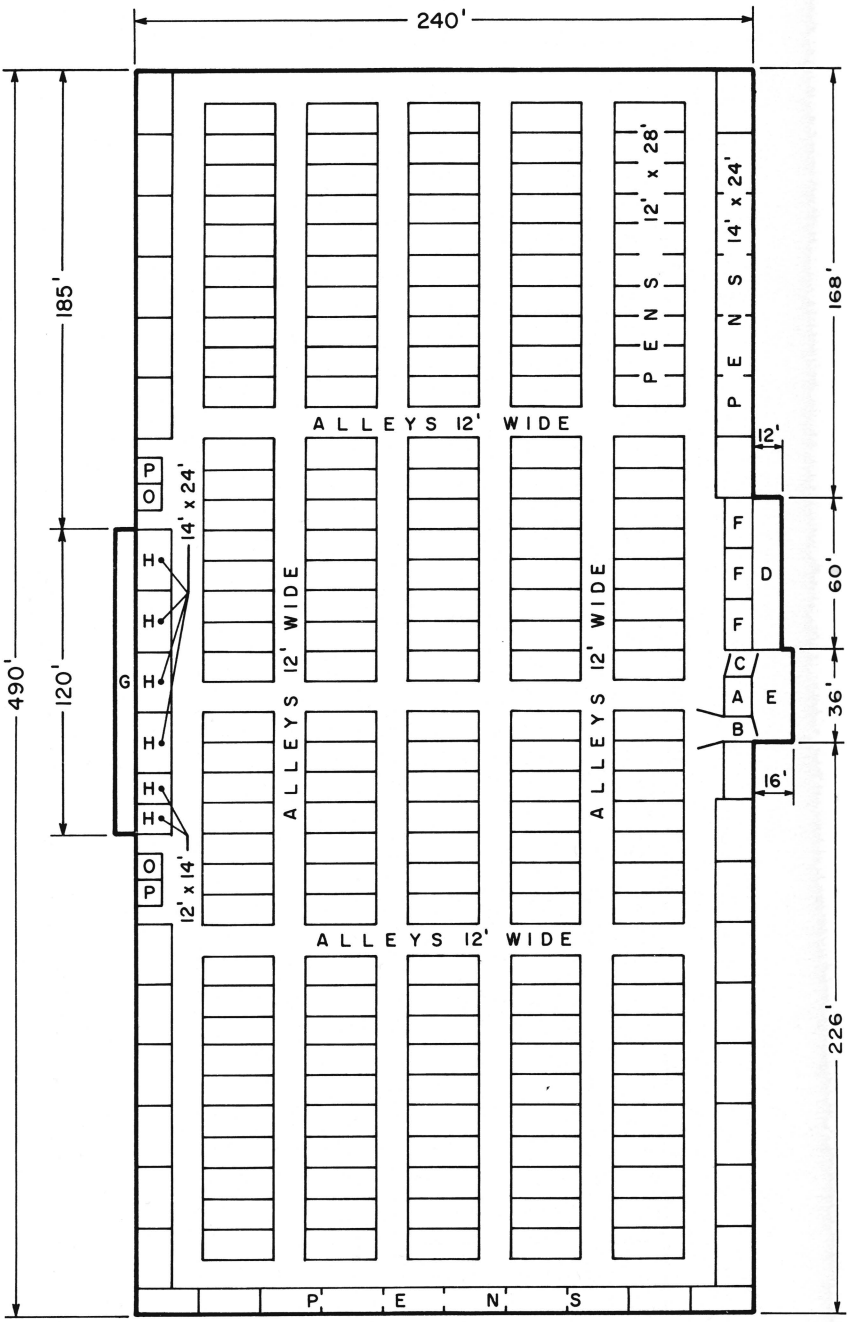

Figure 3. Model Auction C, 2,500 Animal Unit Daily Capacity.

organizations to clean out the pens and alleys at no cost to the auctions. These organizations then sell the manure and bedding. It was therefore assumed that the revenue from the sale of this "waste" product equalled the cost of

TABLE 4

Calculated Unit and Total Costs of Building Construction of Model Auction A – 500 Animal Unit Capacity

Item, Number of Units, and Cost Per Unit[a]	Total Cost
Fencing and Gates, 3,498 linear feet @ $3.82/ft.	$13,362.36
Hayracks and Feed Troughs @ $1.50/A U capacity[b]	525.00
Water Troughs @ $0.14/A.U. capacity[b]	70.00
Water Lines @ $2.50/A.U. capacity[b]	1,250.00
Yard Lighting @ $1.30/A.U. capacity[b]	650.00
Scale Platform and House	3,819.20
Sales Barn, 3,060 Square Feet @ $4.77/Sq. Ft.[c]	14,596.20
Theater Seats, 213 @ $7.50	1,597.50
Public Address System	818.00
Ticket Carrier System	1,364.00
Sanitary Sewers	1,023.00
Docks, Chute and Chute Pens, 72 front linear feet @$29.05/ft.	2,091.60
Concrete Paving (Pens and Alleys), 28,296 sq. ft. @ $0.47/Sq. Ft.	13,299.12
Roofing, 27,720 Sq. Ft. @ $0.82/Sq. Ft.	22,730.40
Paving (Driveways, dock approaches, roads, and parking areas - rolled gravel), 138,600 Sq. Ft. @ $0.09	12,474.00
TOTAL	**$89,670.38**

[a]Costs per unit were taken from Brasington, *op. cit.* pp. 38, 55, 69, and updated from 1957 to 1970. They were updated by means of the "Historical Building Cost Index." The average of all building types in the Pittsburgh area had an index number of 234.1 in 1957. The 1970 figure for the first two quarter average in the same area was 319.3 indicating a 36.4 per cent increase from 1957 to 1970 in building costs. *The Architectural Record,* Vol. 143, No. 7, and Vol. 148, No. 2, New York: McGraw Hill, June, 1968 and August, 1970.

[b]The unit costs were based on the number of animal units the model auction was capable of handling at capacity (500 A.U.'s).

[c]The cost per square foot of $4.77 includes wood frame construction of the sales barn, stairs, auction box, offices, restaurant, rest rooms, and storage areas. The estimate includes all electrical and lighting work, plumbing, and toilet facilities.

equipment for removing it. Pen and alley cleaning equipment was, therefore, omitted from consideration as a cost in this study.

TABLE 5

Calculated Unit and Total Costs of Building Construction of Model Auction B – 1,500 Animal Unit Capacity

Item, Number of Units, and Cost Per Unit[a]	Total Cost
Fencing and Gates, 8,962 linear feet @ $3.82/Ft.	$34,234.84
Hayracks and Feed Troughs, @ $1.05/AU Capacity[b]	1,575.00
Water Troughs @ $0.14/AU Capacity[b]	210.00
Water Lines @ $2.50/AU Capacity[b]	3,750.00
Yard Lighting @ $1.30/AU Capacity[b]	1,950.00
(2) Scales, Platforms, and Houses	7,638.40
Sales Barn, 4,545 Sq. Ft. @ $4.77/Sq. Ft.[c]	21,679.65
Theater Seats, 300 @ $7.50	2,250.00
Public Address System	818.00
Ticket Carrier System	1,364.00
Sanitary Sewers	1,023.00
Docks, Chute, and Chute Pens, 120 front linear feet @ $29.05/Ft.	3,486.00
Concrete Paving (Pens and Alleys) 70,416 Sq. Ft. @ $0.47/Sq. Ft.	33,095.52
Roofing, 69,840 Sq. Ft. @ $0.82	57,268.80
Paving (driveways, dock approaches, roads, and parking areas – rolled gravel), 349,200 Sq. Ft. @ $0.09	31,428.00
TOTAL	**$201,771.21**

[a]Costs per unit were taken from Brasington, *op. cit.* pp. 38, 55, 69, and updated from 1957 to 1970. They were updated by means of the "Historical Building Cost Index." The average of all building types in the Pittsburgh area had an index number of 234.1 in 1957. The 1970 figure for the first two quarter average in the same area was 319.3 indicating a 36.4 per cent increase from 1957 to 1970 in building costs. *The Architectural Record,* Vol. 143, No. 7, and Vol. 148, No. 2 New York: McGraw Hill, June, 1968 and August, 1970.

[b]The unit costs were based on the number of animal units the model auction was capable of handling at capacity (1,500 A.U.'s).

[c]The cost per square foot of $4.77 includes wood frame construction of the sales barn, stairs, auction box, offices, restaurant, rest rooms, and storage areas. The estimate includes all electrical and lighting work, plumbing, and toilet facilities.

Restaurant Equipment

According to the same authorities, restaurants are often operated through leasing or other agreements by persons not involved in auction ownership or

TABLE 6

Calculated Unit and Total Costs of Building Construction of Model Auction C – 2,500 Animal Unit Capacity

Item, Number of Units, and Cost Per Unit[a]	Total Cost
Fencing and Gates, 14,488 linear feet @ $3.82/Ft.	$55,344.16
Hayracks and Feed Troughs, @ $1.05/AU Capacity[b]	2,625.00
Water Troughs, @ $0.14/AU Capacity[b]	350.00
Water lines, @ $2.50/AU Capacity[b]	6,250.00
Yard lighting, @ $1.30/AU Capacity[b]	3,250.00
(2) Scales, Platforms, and Houses	7,638.40
Sales Barn, 4,545 Sp. Ft. @ $4.77/Sq. Ft.[c]	21,679.65
Theater Seats – 300 @ $7.50	2,250.00
Public Address System	818.00
Ticket Carrier System	1,364.00
Sanitary Sewers	1,023.00
Docks, Chute, and Chute pens, 120 front linear feet @ $29.05/Ft.	3,486.00
Concrete Paving (Pens and Alleys), 118,896 Sq. Ft. @ $0.47	55,881.12
Roofing, 118,320 Sq. Ft. @ $0.82	97,022.44
Paving (driveways, dock approaches, roads, and parking areas – rolled gravel), 591,600 Sq. Ft. @ $0.09	53,244.00
TOTAL	**$312,225.73**

[a]Costs per unit were taken from Brasington, *op. cit.* pp. 38, 55, 69, and updated from 1957 to 1970. They were updated by means of the "Historical Building Cost Index." The average of all building types in the Pittsburgh area had an index number of 234.1 in 1957. The 1970 figure for the first two quarter average in the same area was 319.3 indicating a 36.4 percent increase from 1957 to 1970 in building costs. *The Agricultural Record,* Vol. 143, No. 7, and Vol. 148, No. 2 New York: McGraw Hill, June, 1968 and August, 1970.

[b]The unit costs were based on the number of animal units the model auction was capable of handling at capacity (2,500 A.U.'s).

[c]The cost per square foot of $4.77 includes wood frame construction of the sales barn, stairs, auction box, offices, restaurant, rest rooms, and storage areas. The estimate includes all electrical and lighting work, plumbing, and toilet facilities.

management. Therefore, the cost of restaurant equipment was assumed to equal the revenue from restaurant sales, and this equipment cost was also omitted from the study.

Office Equipment

Office equipment requirements and costs were based on office labor requirements. The requirements were found to be the same for each of the model auction markets. The prices were taken from 1970 published catalogues of various office equipment suppliers (Table 7). The total cost of office equipment was $2,921, including the three per cent West Virginia sales tax, for each of the model auctions.

EQUIPMENT DEPRECIATION

Equipment depreciation was based on an expected lifetime of 12.5 years. Assuming a salvage value of zero, the rate was eight per cent per year.

TABLE 7

Office Equipment Requirements and Costs

Item(s) and Unit Costs	Total Cost
Secretary Desks (2), 60" x 30", @ $313.75[a]	$ 627.50
Office Desk, 60" x 30", @ $260.50[a]	260.50
Leg Base Table, 60" x 30", @ $153.25[a]	153.25
Swivel Arm Chair, @ $152.80[a]	152.80
Secretary Chairs (2), @ $104.40[a]	208.80
Side Chairs (2), @ $70.40[a]	140.80
File Cabinet, Lock, Five Drawer (2) @ $194.75[a]	389.50
Electric Typewriters (2) @ $325.00[b]	650.00
Adding Machine, @ $153.00[c]	153.00
Miscellaneous Equipment[d]	100.00
TOTAL	2,836.15
Tax @ 3%	85.08
TOTAL (INCLUDING TAX)	$2,921.23

[a]All-Steel Equipment Company, Aurora, Illinois.

[b]International Business Machines, White Plains, New York.

[c]Monroe International, Inc., Orange, New Jersey.

[d]Includes items such as bookcases, pencil sharpeners, staples, desk files, etc.

Accordingly, the annual equipment depreciation for each model operation was $234.

LAND REQUIREMENTS AND COSTS

The total land area required for an auction market including the auction yard and barn space, driveways, parking areas, and areas for expansion amounted to about ten times the area required for yard space.[22] According to the Morgantown (W. Va.) Chamber of Commerce an area of land in West Virginia outside the city limits with access to all necessary services (fire protection, sewage, water, etc.) would cost $1,000 per acre.

The total land area required for model auction A was assumed to be 277,200 square feet (ten times the area of pens and alleys). Model auctions B and C required 698,000 and 1,183,200 square feet, respectively. The total cost of land for the three model auctions was $6,362, $16,019, and $27,154 for model auctions A, B, and C, respectively.

UTILITIES

The utilities considered as costs in this study were telephone, electricity, water, sewage, and gas.

Telephone

The intensity of telephone use seemed to vary between different sized livestock auctions. Some markets used the phone heavily for advertising while others relied on other means.

In order to develop an estimate of what the telephone would be expected to cost in model livestock auctions, two factors were examined: (1) the telephone costs reported by West Virginia livestock auctions to the Commissioner of Agriculture in 1969, and (2) the number of animal units handled in that year by each of these reporting markets. A simple linear regression was computed and the following equation was developed:

$$Y = 43.3521 + \underset{(.0087)}{.0493}\ X$$

$$r^2 = 0.70$$

Y = Annual Phone Bill (Dollars)
X = Animal Units Handled Annually

In model auctions A (9,240 A.U.'s), B (27,720 A.U.'s), and C (46,200 A.U.'s) the respective annual cost of telephones was $499, $1,410, and $2,321.

[22] *Ibid.*, p. 37.

Electricity

According to Brasington, "a string of 100 watt lights about 40 feet apart should be centered over the alleys, and another string of 100 watt lights about 40 feet apart should be centered over each row of pens."[23] The number of bulbs required for the alley and pen area was determined, based on this rule of thumb. The number of bulbs required for the offices and sales barn was estimated by Experiment Station personnel. The total number of 100 watt bulbs estimated to be required for the three model auctions was 86, 188, and 274 for model auctions A, B, and C, respectively.

It was assumed, since each auction was open for only one sale day per week, that lighting would be required for 24 hours per week. The extra time was included to account for early deliveries of livestock to the auction and for later pick-ups of animals that were already sold.

In order to determine the annual consumption of electricity in kilowatt hours (K.W.H.), the following equation was specified by the local power company:

$$\text{Annual Consumption of Electricity in Kilowatt Hours} = \frac{\text{number of lamps X watts per lamp X hours of use}}{\text{1,000 (watts per K.W.H.)}}$$

The annual consumption of electricity for the three model auctions was therefore determined to be 10,733, 23,462, and 34,195 K.W.H.'s for model plants A, B, and C, respectively. The monthly commercial rate schedule that would be assigned to auction markets was specified by the Monongahela Power Company as indicative of the rates that could be expected in West Virginia:

1st 50 K.W.H.	$2.80
Next 350 K.W.H.	0.043 per K.W.H.
Next 600 K.W.H.	0.032 per K.W.H.
All over 1,000 K.W.H.	0.026 per K.W.H.

Accordingly, the annual cost of electricity estimated for the model auction markets was $404, $743, and $974 for model auctions A, B, and C, respectively.

Water and Sewage

The average cow (animal unit) handled by a livestock auction could be expected to drink 12 gallons of water per day, according to an interview with personnel from the Division of Animal and Veterinary Sciences of West Virginia University. Five per cent of the animal units handled by livestock auctions were assumed to drink a day's water supply. Based on these assumptions it was calculated that 5,544, 16,632, and 27,720 gallons of water would be consumed annually in model auctions A, B, and C, respectively.

The rate schedules for water and sewage were reported by the Morgantown Water Commission as indicative of water and sewage rates in West Virginia:

[23] *Ibid.*, p. 32.

Water Rate Schedule (per three months)		Sewage Rate Schedule (per three months)	
1st 6,000 gal.	$0.87/1000 gal.	1st 6,000 gal.	$0.78/1000 gal.
Next 24,000 gal.	0.59/1000 gal.	Next 24,000 gal.	0.55/1000 gal.
Next 60,000 gal.	0.49/1000 gal.	Next 60,000 gal.	0.46/1000 gal.
Next 90,000 gal.	0.40/1000 gal.	Next 90,000 gal.	0.38/1000 gal.
All over 180,000 gal. . . .	0.30/1000 gal.	All over 180,000 gal. . . .	0.29/1000 gal.

The cost of water and sewage for the three model auctions on an annual basis was calculated to be $30, $30, and $44, respectively, for model auctions A, B, and C.[24]

Natural Gas

Hope Natural Gas Company, in Morgantown, West Virginia, was contacted regarding heating costs. Annual heating costs are based on the number of cubic feet in the building to be heated. The sales barn, restaurant, office, and storage areas for model auctions A, B, and C accounted for about 50,000, 62,000, and 62,000 cubic feet of space, respectively.

The annual rates for gas consumption are determined by means of the following equation:

$$\text{Annual Cost of Gas} = \frac{\text{B.T.U.'s required} \times \text{number of heating hours per year} \times \$0.81}{1{,}000{,}000}$$

The gas company representative reported that for buildings such as those used in this study, model auction A would require 4.5 B.T.U.'s per cubic foot per hour and model auctions B and C would each require 3.5 B.T.U.'s per cubic foot per hour. The total number of B.T.U.'s required was determined by multiplying the number of B.T.U.'s required per cubic foot times the total number of cubic feet in each model auction.

According to the gas company representative, the average number of hours of heating required in West Virginia is 1,819. It was assumed that since a livestock auction has only one sale per week, heating would only be necessary for three days per week. This would account for people working one day prior to the sale and one day following the sale. Therefore it was reasoned that 3/7 of the total number of heating hours required per year in the State, or 780 heating hours, would be required for each model livestock auction per year.

The annual cost of gas for model plants A, B, and C was calculated to be $142, $137, and $137, respectively.

Total Annual Utilities Costs

The total annual cost of utilities is summarized in Table 8 for all model livestock auctions.

[24]Sewage rates are determined on the basis of fresh water consumption. There was a minimum charge of $5.20 for water consumption and $4.68 for sewage for each three-month period. It should also be noted that water consumption in the sales barn was assumed to be included in the figures derived above, based on consumption of water by livestock.

TABLE 8

Calculated Total Annual Cost of Utilities in the Model Livestock Auctions

Utility	Model Auction A	Model Auction B	Model Auction C
Telephone	$ 499	$1,410	$2,321
Electricity	404	743	974
Water & Sewage	30	30	44
Natural Gas	142	137	137
TOTAL	**$1,075**	**$2,320**	**$3,476**

OPERATING COSTS

Operating costs were estimated for each of the model auctions. They included supplies, losses, market-news service, feed costs, transportation and gasoline costs, repair and maintenance, and miscellaneous costs.

Supplies

This category of operating costs included consignor and buyer sheets, bank checks, animal markers, manure forks, prods, etc. Murra and Mire reported that supplies accounted for $0.10, $0.08, and $0.10 per animal unit (one cow: one calf: three hogs: seven sheep or lambs) in small, medium, and large auctions, respectively, in Louisiana.[25] The Louisiana costs per animal unit were converted into the same animal units that were used in the present study[26] and the figures were inflated for changes in the price level from 1964 to 1970.[27] Accordingly, the annual cost of supplies was $1,066, $2,560, and $5,332 for model auctions A, B, and C, respectively.

[25]Murra and Mire, *op. cit.*, p. 30.

[26]One cattle: two calves: four hogs: four sheep or lambs. One animal unit in the present study is equivalent to 0.995 animal unit used by Murra and Mire.

[27]The increase in the Wholesale Price Index was from 100.5 in 1964 to 116.6 in 1970 indicating a 16 per cent increase. *Statistical Abstract of the United States, 1970,* U.S. Dept. of Commerce, Bureau of the Census, Washington, D.C.: U.S. Government Printing Office, 1970, p. 339.

Losses

This category included bad debts, death losses, refunds, adjustments, etc. The annual costs for this cateogry were determined in the same manner as the annual cost of supplies. Murra and Mire reported that losses accounted for $0.07, $0.05, and $0.09 per animal unit (see footnote 26) for small, medium, and large auctions in Louisiana.[28] The costs per Louisiana animal unit were converted to the same animal units used in this study and were updated from 1964 to 1970 for changes in the price level (see footnote 27). The annual costs to the model livestock auction markets for losses amounted to $750, $1,608, and $4,823 for model auctions A, B, and C, respectively.

Market News Service

The market news service is used for advertising and price reporting. Wilson and Kuehn reported that the costs per Livestock Marketing Unit (LMU) were $0.13 and $0.10 for West Virginia auctions handling from 6,000 to 11,999 LMU's and for 12,000 or more LMU's per year, respectively.[29] The costs per LMU were converted to costs per animal unit (1.130 LMU's = 1 animal unit) and the former figure was used ($0.13 per LMU) for model auction A and the latter figure ($0.10 per LMU) for model auctions B and C. The figures were inflated for increases in the price level from 1967 to 1970 of 9.9 per cent,[30] and the total annual market news service cost came to $1,493, $3,342, and $5,737 for model auctions A, B, and C, respectively.

Feed Costs

Based on an interview with West Virginia State Department of Agriculture personnel, about five per cent of all animal units handled by auctions in West Virginia consume feed. Several suppliers were contacted who reported that the average cost of hay was $0.50 per bale or $20.00 per ton. Assuming that an average animal unit consumes 20 pounds of hay per day or 0.01 ton per day, the cost per animal unit that consumed feed was calculated to be $0.20. Accordingly, the total annual cost of feed was $92, $277, and $462 for model auctions A, B, and C, respectively.

Transportation and Gasoline

The annual cost of transportation and gasoline was also calculated based on coefficients derived from actual West Virginia auction markets by Wilson and Kuehn.[31] Transportation and gasoline was reported to cost $0.04 and $0.03 per

[28]Murra and Mire, *op. cit.*, p. 30.

[29]Wilson and Kuehn, *op. cit.*, p. 26. One Livestock Marketing Unit (LMU) was equivalent to one "cattle" or three calves or four hogs or five sheep or lambs.

[30]*Statistical Abstract of the United States, 1970, op. cit.*, p. 339.

[31]Wilson and Kuehn, *op. cit.*

LMU by auctions handling from 6,000 to 11,999 LMU's per year and by auctions handling over 12,000 LMU's per year, respectively.[32] The coefficients were converted from costs per LMU to costs per animal unit and were inflated 9.9 per cent for price level increases from 1967 to 1970. The annual cost of transportation and gasoline was calculated at $457, $1,036, and $1,726 for model auctions A, B, and C, respectively.

Repairs and Maintenance

Repairs and maintenance costs are both variable and fixed in nature. They are highly variable between markets, depending on the relative age and condition of buildings and equipment. A rule of thumb that has been used before in economic engineering analyses was used to estimate repairs and maintenance costs.[33] Annual repairs and maintenance costs were assumed to equal one per cent of the initial cost of buildings and five per cent of the initial cost of equipment. The annual cost was calculated to be $1,029, $2,150, and $3,255 for model auctions A, B, and C, respectively.

Miscellaneous Costs

Miscellaneous operating costs included legal fees, scale testing fees, linen service, veterinary fees, etc. These costs averaged six per cent of the variable costs in the Louisiana auction market study.[34] Cost per animal unit in the Louisiana study was $0.21, $0.17, and $0.17 in small, medium, and large Louisiana auctions.[35] The Louisiana figures were converted for the different calculations of animal units and were adjusted for price level changes from 1964 to 1970. The estimates for the present study were calculated to be $2,240, $5,434, and $9,057 for model auctions A, B, and C, respectively.

Total Operating Costs

All operating costs are summarized in Table 9. They amounted to $7,127, $16,507, and $30,392 for model auctions A, B, and C, respectively.

ANNUAL INVESTMENT COSTS

Annual investment costs include charges for building and equipment depreciation, insurance, taxes, and interest on land, buildings, and equipment.

[32] *Ibid.*, p. 26.

[33] Burgess, Roy, "Cost Analysis of Whole-Hog Sausage Processing Plants," Unpublished Master's thesis, The University of Tennessee, December, 1962, p. 22, and Kuehn, John P., "Costs and Efficiencies of Model Meat Packing Plants in the Tennessee Valley," Unpublished Doctoral dissertation, The University of Tennessee, December, 1969, p. 93.

[34] Murra and Mire, *op. cit.*, p. 32.

[35] *Ibid.*

TABLE 9

Calculated Total Annual Operating Costs of the Model Livestock Auctions

Cost Item	Model Auction A	Model Auction B	Model Auction C
Supplies	$1,066	$ 2,560	$ 5,332
Losses	750	1,608	4,823
Market News Service	1,493	3,442	5,737
Feed	92	277	462
Transportation and Gasoline	457	1,036	1,726
Repairs & Maintenance	1,029	2,150	3,255
Miscellaneous	2,240	5,434	9,057
TOTAL	**$7,127**	**$16,507**	**$30,392**

Building and Equipment Depreciation

These items were calculated earlier in this report under the building and equipment cost headings.

Insurance

A local insurance company was contacted and asked to quote the rates for liability and fire insurance and bonds for employees that handle currency.

Liability insurance for bodily injury for a maximum of $100,000 per person injured and for a maximum of $300,000 per occurance and property damage coverage of up to $25,000 per person and a maximum of $100,000 per occurrance was reported to cost 2.021 per cent of the annual auction payroll for one year's coverage.

The annual cost of fire insurance and extended coverage for the type of

buildings designed for the model auctions in this study was quoted at 1.8 per cent of the total value of buildings.

The cost of security bonds for a maximum deficit of $25,000 was quoted at a flat rate of $170 per year.

The total annual cost of liability and fire insurance and bonds was calculated to be $2,134, $4,471, and $6,771 for model auctions A, B, and C, respectively.

Personal Property Tax

The Monongalia County Assessor's Office was contacted regarding the personal property tax rates for livestock auction markets in West Virginia. The rate for Class II personal property[36] was assessed on 50 per cent of the appraised value. The rate for 1970 was 2.418 per cent of the assessed value of land, buildings, and equipment. The annual personal property taxes for model auctions A, B, and C were calculated at $1,180, $2,652, and $4,122, respectively.

Interest

Annual interest on land, buildings, and equipment was based on the full cost of land and on 50 per cent of the initial cost of buildings and equipment, assuming their value would be zero at the end of the depreciation period. The 1970 "Prime Banker's Acceptances" rate of interest was 7.6 per cent.[37] Accordingly, the annual interest for model auctions A, B, and C was $4,002, $8,996, and $14,077, respectively.

Total Annual Investment Cost

Total annual investment costs of the model livestock auctions are summarized in Table 10.

Total Annual Cost

Total annual cost for each of the model livestock auctions was calculated by summing the following costs: total annual labor cost, total annual cost of utilities, operating costs, and annual investment costs. The total annual cost for each model operation was divided by the number of animal units handled annually to determine the cost per animal unit (Table 11).

COST ANALYSIS

The synthetically determined costs per animal unit of $4.12, $2.82, and $2.66 for the three model auctions are indications of costs which would be

[36]Class II land is defined as "All real and personal property situated outside of municipalities excluding Classes I and III."

[37]*Statistical Abstract of the United States, 1970, op. cit.,* p. 453.

TABLE 10

Calculated Total Annual Investment Costs of the Model Livestock Auctions

Cost Item	Model Auction A	Model Auction B	Model Auction C
Building Depreciation	$ 3,587	$ 8,070	$12,489
Equipment Depreciation	234	234	234
Insurance	2,134	4,471	6,771
Taxes	1,180	2,652	4,122
Interest	4,002	8,996	14,077
TOTAL	**$11,137**	**$24,423**	**$37,693**

incurred in efficient markets operating under West Virginia economic conditions. As the size of the auction market increased (in terms of animal unit capacity), the cost per animal unit decreased. The decrease in unit cost was quite large ($1.30) between model auction A (500 animal unit capacity) and model auction B (1,500 animal unit capacity). The decrease in unit cost between model auctions B and C (2,500 animal unit capacity) was not as great ($0.16). However, economies of size were indicated.

Since the model auctions in this study were designed to operate under expected West Virginia economic conditions, they were not assumed to operate at full capacity all year round. The number of animal units they were assumed to handle was based on actual marketings of livestock in West Virginia which are highly seasonal in nature. The result of this assumption was that the model auctions operated at full capacity only during one month of the year. If the model auctions operated at year-round full capacity, the unit costs would have been substantially lower than the estimates of costs under expected marketing conditions.

If model auction A, for example, operated at full capacity all year, the

TABLE 11

Calculated Total Annual Cost and Cost per Animal Unit of the Model Livestock Auctions

Cost Item	Model Auction A	Model Auction B	Model Auction C
Total Annual Labor Cost[a]	$18,760	$34,943	$ 51,156
Total Annual Cost of Utilities[b]	1,075	2,320	3,476
Operating Costs[c]	7,127	16,507	30,392
Annual Investment Costs[d]	11,137	24,423	37,693
Total Annual Cost	**$38,099**	**$78,193**	**$122,717**
Annual Output (A.U.'s)[e]	**9,240**	**27,720**	**46,200**
Cost Per Animal Unit	**$4.12**	**$2.82**	**$2.66**

[a]Taken from Table 3
[b]Taken from Table 8
[c]Taken from Table 9
[d]Taken from Table 10
[e]Taken from Table 2

number of animal units handled by this auction would increase from 9,240 to 26,000, assuming only one sale day per week. The cost per animal unit would decrease from the $4.12 mentioned earlier to $3.27.[38] The number of animal units handled by model auctions B and C would increase from 27,720 to 78,000 and from 46,200 to 130,000, respectively. Their unit costs would decrease from

[38]The figure of $3.27 per animal unit was derived by assuming the cost of utilities and investment costs remained the same as output increased. Labor and operating costs were increased in proportion to the change in the number of animal units handled. It should be noted, however, that unit labor and operating costs may not increase in strict proportion to an increase in output of this magnitude.

$2.82 to $2.20 in model auction B and from $2.66 to $2.09 in model auction C. Capacity utilization, therefore, appears to be an important factor in auction marketing costs. Existing auctions in the State have the capacity to increase the number of animals they handle by about 280 per cent, yet they are handicapped by the seasonal nature of livestock marketings.

Optimum Size Auction Market

The objective of many economic engineering studies is to determine the optimum scale of plant. This optimum scale is found at the minimum point of the long-run average cost curve. The long-run average cost curve can be defined as "showing the least possible cost per unit of producing various outputs when the firm has time to build any desired scale of plant."[39] The technique of economic engineering has advantages in estimating a "long-run average cost curve." A series of firms of differing scales can be "constructed" in model form and the short-run average cost curve can be derived for each of the model firms. This derivation was accomplished in the present study by developing a series of short-run unit costs for each model auction based on varying levels of output. Output was varied from 50 per cent above "expected output"[40] to 50 per cent below expected output. Table 12 shows the total cost, total output, and cost per unit of output of the model firms under varying rates of output. The short-run average cost curves are presented in graphic form in Figure 4.

From Figure 4, it can be seen that average cost decreases as output increases. However, due to a substantial degree of unused capacity, none of the model firms is approaching the minimum point on the average cost curve. It does not appear that this minimum point can be reached until a model auction approaches or exceeds capacity output. These short-run average cost curves do, however, provide an indication of efficiency of firms which are forced to operate under less than capacity conditions. Points a, b, and c show the average costs at expected outputs of model firms A, B, and C. The points above and below the expected outputs show the outputs and unit costs of each model auction varying 50 per cent above and below the expected output. The dashed sections of the three average cost curves show the behavior of unit costs as the firm approaches "capacity." Points d, e, and f are the costs per animal unit when the model plants are operating at "capacity."[41] It may be deduced from this Figure that the most efficient firm for producing 4,620 to about 15,000 animal units is Auction A. Auction B would be the most efficient size firm for handling 15,000

[39]Leftwich, Richard H., *The Price System and Resource Allocation,* New York: Holt, Rinehart and Winston, Revised ed., 1962, p. 153.

[40]Expected output was determined earlier in this report in the section on Annual Output. It was based on the capacities of model plants and on the actual seasonal marketings of livestock in West Virginia.

[41]Capacity in this case is limited by the assumption that the firm conducts only one sale per week (see footnote 38).

TABLE 12

Total Cost, Total Output, and Cost per Unit of Output of the Model Firms Under Varying Rates of Output

Rate of Capacity Utilization Above and Below Expected Output (%)	Model Auction A			Model Auction B			Model Auction C		
	Total Cost[a]	Annual Output[b] (number)	Unit Cost[c]	Total Cost[a]	Annual Output[b] (number)	Unit Cost[c]	Total Cost[a]	Annual Output[b] (number)	Unit Cost[c]
+50	$51,042	13,860	$3.68	$103,920	41,580	$2.50	$163,491	69,300	$2.36
+40	48,454	12,936	3.75	98,774	38,808	2.55	155,336	64,680	2.40
+30	45,865	12,012	3.82	93,629	36,036	2.60	147,180	60,060	2.45
+20	43,276	11,088	3.90	88,485	33,264	2.66	139,026	55,440	2.51
+10	40,687	10,164	4.00	83,339	30,492	2.73	130,871	50,820	2.58
Expected Output	38,099	9,240	4.12	78,193	27,720	2.82	122,717	46,200	2.66
-10	35,510	8,316	4.27	73,049	24,948	2.93	114,562	41,580	2.76
-20	32,921	7,392	4.45	67,904	22,176	3.06	106,407	36,960	2.88
-30	30,333	6,468	4.69	62,759	19,404	3.23	98,252	32,340	3.04
-40	27,744	5,544	5.00	57,613	16,632	3.46	90,097	27,720	3.25
-50	25,155	4,620	5.44	52,469	13,860	3.79	81,943	23,100	3.55

[a]Derived from Tables 3, 8, 9 and 10. Investment and utilities costs were held constant and labor and operating costs were varied as output varied.

[b]Derived from Table 2.

[c]Total cost divided by annual output at each rate of capacity utilization.

to about 100,000 animal units. For outputs greater than 100,000 animal units, Auction C appears to be more efficient.

The long-run average cost curve, theoretically, is a line passing through the minimum points of all short-run average cost curves but not passing above any average cost curve at any point.[42] The optimum size firm then is one which produces at the minimum point on the long-run average cost curve. It appears from Figure 4 that the long-run average cost curve can be derived by drawing an envelope to the three short-run curves, but this curve is downsloping and has no minimum point. Therefore, it appears that the output necessary to decrease long-run costs to a minimum is well beyond the limits defined in this study. However, that segment of a planning curve which can be derived by means of an envelope curve could be useful for planning purposes within the more realistic range of outputs discussed in this report.

[42]Viner, Jacob, "Cost Curves and Supply Curves," *Readings in Price Theory,* eds. George J. Stigler and Kenneth E. Building, Chicago: Richard D. Irwin, Inc., 1952, reprinted from *Zeitschrift Fur National-Okonomie,* 1931, p. 227. It was noted by Viner in 1952 that such a tangent line is not possible to draw in the case of increasing or decreasing costs. For purposes of the present study, it was assumed the line would be tangent to the lowest cost curve associated with each possible output.

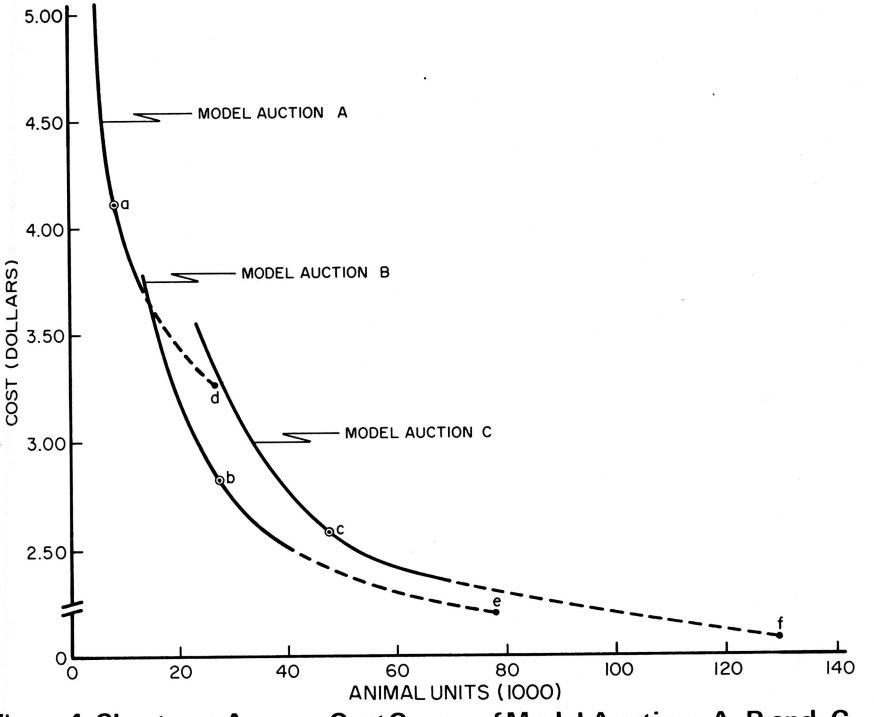

Figure 4. Short-run Average Cost Curves of Model Auctions A, B and C.

It should also be noted that this envelope curve does not strictly adhere to the theoretical notion of long-run average costs. The model auctions were designed based on existing technology. They reflected efficient operating practices and costs at a single point in time. However, in the long-run, technology and operating practices change, and it is not possible in a study of this nature to foresee such changes. It was felt, however, that the planning curve that was derived would provide a useful comparison of "efficient" engineered costs to actual auction costs in West Virginia.

Actual West Virginia Auctions

Wilson and Kuehn investigated the costs of marketing livestock through auctions in West Virginia.[43] Their study was based on the annual reports of livestock auction markets to the West Virginia Commissioner of Agriculture. From these reports, accounting data were used to calculate the costs per unit of output in terms of livestock marketing units for 1967 and 1968.[44] By means of stepwise linear regression analysis, they fitted several functions to the unit cost figures. However, in cost studies of this nature, it has been difficult to identify the type of cost function that was derived.

A true short-run average cost curve is derived by varying the outputs of a single plant in a time period short enough to prohibit changing the scale or fixed factors of that plant. Accounting data used to fit cost curves in regression analyses are based on unit costs of different firms. These unit costs could reflect differences in technical efficiency and differences in economic efficiency. In effect, each of the unit costs is a point on that firm's actual average cost curve. That point may be located on the increasing or decreasing portion of that average cost curve. Furthermore, the accounting procedures could differ among the sample firms.

The usefulness of regression analysis in approximating the long-run cost curve is also questionable. The use of different sample firms, each with a fixed technological organization of physical facilities, the fact that the accounting data are fixed in one time period and the fact that a regression equation estimates an "average" of a scatter of points rather than an envelope of minimum points, all preclude the use of this type of analysis for estimating long-run average costs.

Given these qualifications, the following quadratic function, derived by Wilson and Kuehn, was examined:

$$Y_t = 509.72 - 1.8484\ X_1 + 0.0054\ X_2$$
$$(0.6357) \qquad (0.0026)$$
$$R^2 = 0.75$$

[43]Wilson and Kuehn, *op. cit.*

[44]See footnote 15.

where,

Y_t = Total cost per livestock marketing unit in cents;
X_1 = Hundreds of livestock marketing units handled in a year;
X_2 = Squared value of X_1[45]

The livestock marketing units in the quadratic function were converted into animal units and the resulting curve was presented in Figure 5. The dashed portion of the curve emphasized that it was extended beyond the range of sizes (in terms of animal units handled) of the sample West Virginia auctions.

The engineered planning curve derived from Figure 4 is also shown in Figure 5. Points a and b correspond to points a and b in Figure 4. The two curves intersect near the point of 15,000 animal units. Since the regression curve is an average of a scatter of unit cost points, actual firms in the State incur costs per animal unit both above and below the regression line. In the range of annual output of 10,000 to 20,000 animal units the engineered costs are similar to actual unit costs in West Virginia.

Assuming the accounting procedures used by West Virginia auctions are compatable with those used for the engineered model firms and assuming the engineered costs reflect costs which would be incurred by "efficient" firms, the auction markets in the State may be operating as efficiently as possible given their problem of less than full utilization of capacity.

[45]Wilson and Kuehn, *op. cit.*, p. 27.

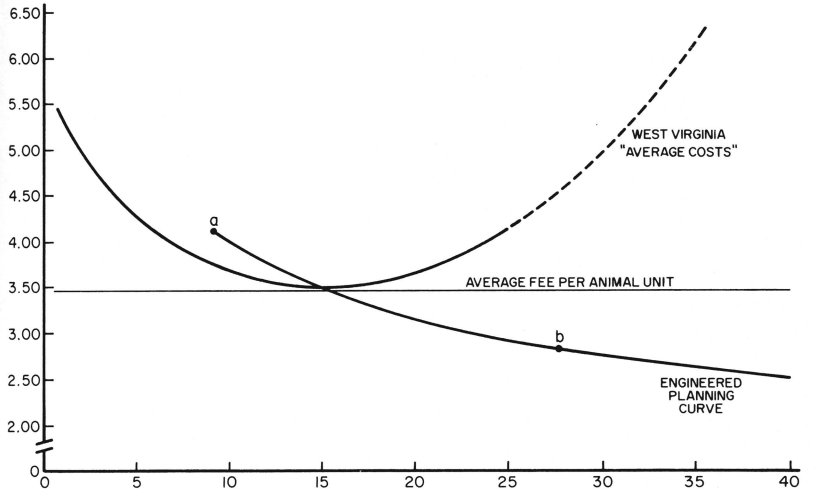

Figure 5. "Average Costs," Engineered Costs and the Average Fee per Animal Unit in West Virginia.

Revenue Per Animal Unit

West Virginia Department of Agriculture representatives were contacted and it was found that auction fees in the State are set on an annual basis. Each market manager submits an annual statement of his proposed fees to the State Department of Agriculture. State Department personnel evaluate the request on a comparative basis with the other auction markets in West Virginia. If the proposed fees are not substantially different from the competing auction markets, the fee schedule is approved and must be adhered to for 12 months. The object of this system, according to West Virginia Department of Agriculture representatives, is to prevent unfair competition.

In order to examine the economic situation of the West Virginia auctions more closely, it was decided to compute revenues per animal unit. The posted tariff sheets for each of the auctions operating in West Virginia (1970) were collected and the estimated revenue per animal unit was calculated for each firm.[46] The data were fitted to both a linear and a quadratic function; however, the correlation coefficients were so low (0.26 in the linear regression and 0.42 in the case of the quadratic) that, for comparative purposes, it was decided to use a simple average of all auction market fees per animal unit in the State.

The fees (revenue) per animal unit ranged from $2.93 to $4.43 and the average fee was $3.49 (Figure 5). For comparative purposes, the simple average of the costs per animal unit of the existing West Virginia auctions was found to be $3.66.[47] This negative $0.17 difference between the mean average revenue and the mean average costs of existing firms in the State has implications with respect to the economic stability of the livestock auction industry in West Virginia.

CONCLUSIONS

The costs of handling livestock in West Virginia auctions were similar to the synthetically derived "efficient," engineered costs. Based on this comparison, it did not appear that the auction costs in the State could be substantially decreased without an increase in the number of animal units marketed through auctions. The auctions appeared to be operating as "efficiently" as possible (on an average basis) under the existing market conditions. On the other hand, mean average revenue per animal unit was relatively fixed, on an annual basis, and this figure was $0.17 below the mean average cost.

[46]The revenue per animal unit was based on the revenue which would be received from the sale of cattle (800 lb.) valued at $143.01 per head. Calculated from the 1968 Annual Reports of Livestock Auction Markets to the Commissioner of Agriculture, West Virginia Department of Agriculture, Charleston.

[47]This was calculated by dividing total annual cost per livestock auction in West Virginia by the number of animal units handled by each auction in 1968, Wilson and Kuehn, *op. cit.*, p. 18. It should be noted that these were the same figures which were used to fit the quadratic function of West Virginia "average costs" in Figure 5.

The less efficient firms in the industry might be receiving just enough revenue to cover their variable costs, and if revenue does not cover variable costs, firms may cease operating. In fact, auction firms in West Virginia have been exiting from the industry and from 1961 to 1968 the total volume of animals marketed through all West Virginia livestock auctions was also decreasing.[48]

At the present time revenue per animal unit varies between auctions within a range of $1.50 around the mean of $3.49. If these fees either remain stable or increase, it is possible the trend towards marketing fewer animals through livestock auctions might continue. The decreased volume of livestock marketed through auctions could result in still higher unit costs until enough firms exit from the industry to allow the remaining firms to increase their volumes sufficiently to decrease unit costs.

If the economic conditions interpreted from the present analysis continue, it would appear that the least efficient firms will be forced out of the industry until the volume of livestock marketed through the remaining auctions increases to a point where mean average cost more closely approximates mean average revenue. At this point, it is possible that a temporary equilibrium situation may result.

If, on the other hand, individual firms were allowed to decrease their fees and operate for more than one sale day per week, the level of competition between auctions is likely to increase. The less efficient firms might be forced out of operation and the lower fees may attract a larger volume of livestock to the auction method of marketing. This particular alternative would involve external intervention into the livestock auction industry (possible changes in fee schedules and sale days which are regulated by the State Department of Agriculture). The result, however, will be similar with or without government intervention. The number of auction firms will decrease until mean average cost approaches mean average revenue. The latter case, however, may involve a larger number of animals going through livestock auctions due to competitively reduced fee schedules.

Studies are now underway to determine how many auction firms are needed in West Virginia and where they should be located for maximum economic efficiency. There are also studies being conducted to determine the nature and importance of a trend in the State towards marketing livestock directly to feeders and packers by by-passing the auctions. It is hoped that the present report and future studies in this area will contribute to increasing the overall economic efficiency of West Virginia agriculture and, by so doing, increase the incomes and well-being of our agricultural population.

[48]Wilson and Kuehn, *op. cit.*, pp. 8-10.

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